Drawings

1. Fuel passages (FP) and fuel channel (FC) (as in claim 1, claim 17) is marked on FIG. 2. No new matter has been added for figures.

Claim Objections

2. Claims 11-13 and 19 should be treated based on the merits in view of claim 1 and claim 2;
3. agree with the quotation;
4. other multi-hole conventional orifice refers to most commonly used orifices with multiple channels/holes which introduce fuel into combustion chamber with multiple jets;
5. agree with the quotation;
6. Claims (1,3-5, 17, & 19-20 are valid claims based on following facts:
    - In re claim 1, the said invention gives a fuel injector which is composing a nozzle body and a needle valve which has a converging-diverging conical head, and most importantly, composing a micro-variable-circular-orifice which has means for discharging fuel in variable sprays of conical and conical-multi-jet shapes through said micro-variable-circular-orifice by lifting said needle valve at different magnitudes.
    - Ervin et al. did not disclose such a micro-variable-circular-orifice which has means for discharging fuel in variable sprays of conical and conical-multi-jet shapes through said micro-variable-circular-orifice by lifting said needle valve at different magnitudes.
    - The embodiment by Ervin in FIG. 2 and FIG. 5 are <u>separate embodiments</u> which gives a separate conical and multi-jet spray pattern, no embodiment of a design for combined two spray patterns were given by Ervin in a single injector;
    - <u>FIG. 2 from Ervin can not be modified to produce multi-jets as it may be suggested by anyone, since the orifice is at the same time serves as a sealing surface,</u> no fuel channels can be added at the orifice or above the orifice without invalidating the seal function. Sealing function is a key function for fuel injector; an injector without sealing surface is invalid. In

contrast, Hou's design provides a separate seal surface (2) which is independent of the orifice portion, which can always effectively seal fuel.

- FIG. 5 in Ervin's design is not a working model, which can not be introduced into practice, due the seal surface composing a couple of sliding surfaces which can never practically seal fuel due to expansion (an expansion of few micron meters is sufficient for leaking fuel under high pressure) once subjecting to fuel pressure;
- Ervin's design is fundamentally different from Hou's design in terms of sealing surface (shown in Hou's FIG 2 (2)) and combined spray patterns. Hou's design ensures the injector can sustain high injection pressure for sate-of-the-art advanced combustion. Ervin's design can not sustain high pressure.
- The said invention by Hou provides a unique innovative working design with simple structure for producing variable spray patterns using a single needle valve in a single injector. It has been first introduced into physical prototyping and practice, it is an industrial applicable invention;

Calim1 is amended as following for more clarity (all changes marked in red font):

1. A mixed-mode fuel injector comprising:

(i) a nozzle body (5) comprising passages for fuel (FP), an inner cylindrical space for receiving a needle valve, and a conical surface (C) close to the tip (7) of the nozzle body for guiding a spray of fuel;

(ii) a needle valve (1), which has a converging-diverging conical head for guiding a spray of fuel and which is movable back and forth and received in said nozzle body, wherein said needle valve is at a biased closing position with its seal surface (2) being pressed against nozzle body (5) to block fuel flow, or an opening position defined by driving means; and

(iii) a micro-variable-circular-orifice (4) comprising a variable circular ring aperture between said needle valve and said nozzle body and at least one micro-channel (6), such that fuel is dischargeable in variable sprays of conical and conical-multi-jet shapes through said micro-variable-circular-orifice by lifting said needle valve at different magnitudes.

The validations of claims 3-5, 17, 19-20 follow the same arguments as for claim 1;

In claim 17, fuel channel (FC) has been referred to FIG.2;

7. agree with the quotation;
8. agree with the quotation;
9. Claims 2, 6-16, 18, & 21-23 are patentable due to the same arguments for claim 1, as in term 6 above; more specifically:
    - In re claim 2, the design by Ervin in FIG. 2 and FIG. 5 can never be combined without invalidating the seal surface function. The design in FIG. 2 of Ervin can not be modified to give multiple jets without invalidating the seal surface, and it's not obvious and not feasible that "to one having ordinary skill in the art at the time the invention was made to modify the outlet orifice of the first embodiment of Ervin et al. with the outlet orifice (including the plurality of channels) of the second embodiment of Ervin et al. since such modification would vary the spray pattern"
    - THE MODIFICATION BASED ON ERVIN'S DESIGN WOULD NEVER WORK SINCE IT WILL INVALIDAE THE SEAL SURFACE FOR ERVIN's FIG. 2 AND IT DOES NOT HAVE A VALID SEAL SURFACE FOR FIG. 5; IN FIG. 2, ERVIN USED THE CONICAL ORFICE (at nozzle tip) SERVE AS A SEAL SURFACE, IT CAN NOT BE ADDED CHANNELS (anywhere at the orifice or above) WITHOUT LEAKING FUEL when the needle is in closing position, thus lose the important seal function of injector.
    - In re claims 6, 9-12, and 18, for the said specific new invented injector, it's not obvious to one having ordinary skill in the art at the time the invention was made to select the proper dimensions of components since the new injector has new characteristics which take significant amount of experiments and cost to decide;
    - In re claim 7, it's not obvious or workable to modify Ervin's design to add the micro channels for multi-jet spray pattern, as the similar arguments above;
    - In re claim 8, as discussed above, the embodiments by Ervin in FIG. 2 and FIG. 5 are different designs which can not be combined together in a single injector without invalidating the seal surface function, thus the spray pattern by Ervin can only be EITHER CONICAL OR MULTI-JETS,

CAN NOT be both in a single injector. In claim 8, a typo (2) is corrected as (6);

- In re claim 13, the same argument as in re claim 8, and the said invention by Hou is industrial applicable with a valid seal surface;
- In re claim 14, Ervin's model does not have a valid seal surface, Hou's model has a valid seal surface. Hou provides a single injector with two spray patterns which can be switched to either pattern or both by different needle lift;
- In re claim 15 and 16, Ervin's model can not produce the spray shapes by Hou's model from a single embodiment, neither can Ervin's model produce spray pattern variations from a single injector based on engine loads as does Hou's model. In both claim 15, &16, added "conical surface (C) of" in front of 'nozzle body' for clarity.
- In re claim 21 and 22, combination of said micro-variable circular orifice injector with actively driven means or passively driven means have not been given in prior arts;
- In re claim 23, Ervin's model is in separate embodiments, not in a single embodiment/injector; claim 23 added" wherein fuel is injected through multiple channels in multi-jets into combustion chamber" for clarity of multi-hole orifice.

Conclusion

The applicant has searched the related patents listed by patent examiner, and fund none of the prior art can given variable spray patterns through a single injector with a single needle as defined in the patent application 10/597,000. The applicant believes that the said injector is unique and bears inventions and merits not provided by prior arts, it's applicable for industrial applications. It has been introduced into practical application testing.

Each of the rejections that had been adopted or adopted as modified should be overcome by the arguments presented above, as well as the prior submitted evidence. Reconsideration and withdrawal of each of the rejections are therefore proper and such actions are respectfully requested.

Respectfully submitted,

Deyang Hou

Please recognize our Customer No. 45462

as our correspondence address.